Since most manufacturers with products in the 23 GHz band use common components from their 18 GHz radios, modifications of the higher frequency radios would not require a complete product redesign. Several manufacturers' products already meet or exceed the proposed 0.001% frequency tolerance in the 18 and 23 GHz bands. The 18 month Transition Period would allow manufacturers which do not meet the new standard to recover their investment in existing products and to make the necessary modifications.

Recently, Part 101 rules were published for the Local Multipoint Distribution Service ("LMDS") in the 27.5-31.3 GHz band.[18] The frequency tolerance for LMDS is 0.001%. Part 101 rules also were adopted that relocate the Digital Electronic Message Service ("DEMS") from the 17.7-19.7 GHz band to the 24.25-25.25 GHz band ("24 GHz"). The frequency tolerance for DEMS systems in the 24 GHz band is 0.001% for Nodal Stations and 0.003% for User Stations.[19]

The TIA Fixed Section's proposed frequency tolerance rules are attached in Appendix B, Sections 101.107(a) and 101.139(g). In the proposed rules, a 0.001% frequency tolerance is specified for all Part 101 services between 19.7 and 27.5 GHz. An exception is included in Section 101.107(a), footnote /10/, which references the DEMS regulations of Section 101.507.

The DEMS regulations require 0.001% tolerance for Nodal Stations, but allow 0.003% tolerance for User Stations. The proposed language in Section 101.107(a), footnote /10/, states that stations applied for or licensed prior to the expiration of the 24 month Transition Period in the 19.7 to 27.5 GHz band are grandfathered and may continue to operate after that date with a 0.03% frequency tolerance, provided that they do not cause interference to other licensees.

The TIA Fixed Section's proposed rules for Section 101.107(a) delete the reference to footnote /6/, which states that frequency tolerance specifications apply only to Private Operational Fixed systems. This reference appears to be an error in Part 101. The Part 21 Common Carrier regulations in force in October 1995, before Part 101 was adopted, specify a frequency tolerance of 0.03% for the 19.7-40.0 GHz band.[20] Frequency tolerance requirements should apply equally to Common Carrier and Private users.

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[18] *Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, To Establish Rules and Polices for Local Multipoint Distribution Service, and for Fixed Satellite Services, Second Report and Order, Order on Reconsideration, and Fifth Notice of Proposed Rulemaking*, 12 FCC Rcd 18600 (1997) ("*LMDS Second Report and Order*").

[19] *Amendment of the Commission's Rules to Relocate the Digital Electronic Message Service from the 18 GHz Band to the 24 GHz Band and to Allocate the 24 GHz Band for Fixed Service, Order*, 12 FCC Rcd 3471 (1997) ("*DEMS Order*").

[20] 47 C.F.R. §21.101(a) (1995).

6. Spectrum Efficiency Requirements for the 23 GHz Band

Currently, there are no spectrum efficiency requirements for the 23 GHz band. This lack of standards has, in some cases, resulted in poor spectrum utilization. For example, it is possible for a radio carrying 1.544 Megabits/second, which is equivalent to 24 voice channels, to be licensed for a 50 MHz bandwidth. To encourage more efficient band utilization, the TIA Fixed Section recommends adopting spectrum efficiency requirements in the 23 GHz band.

The TIA Fixed Section's proposed spectrum efficiency rules are included in Appendix B, Sections 101.139(g) and 101.141(a). Under the current Section 101.141(a) rules, a spectrum efficiency rate of 1 bit/second per Hertz is required for all frequency bands below 19.7 GHz and for the DEMS band from 24.25 to 25.25 GHz. The proposed modification to Part 101.141(a) applies the 1 bit/second per Hertz spectrum efficiency requirement to all frequencies below 25.25 GHz, including the 23 GHz band. The spectrum efficiency requirement for the 23 GHz band would be phased in after a Transition Period (18 months for manufacturers and 24 months for licensees, after the date these new rules become effective).

The following table lists the data rates that may be carried in each channel bandwidth, for equipment that meets a 1 bit/second per Hertz requirement:

Channel Bandwidth	Authorized Bandwidth	Spectrum Efficiency	Data Rate	Typical Utilization
MHz	MHz	Bits/sec per Hz	Mbits/Second	
50	50	3.0	155.5	3 STS-1 or OC-3
50	50	2.6	134.1	3 DS3
50	50	1.7	89.4	2 DS3
50	50	1.0	51.8	1 STS-1
40	40	1.1	44.7	1 DS3
30	30	1.2	37.0	24 DS1
20	20	1.2	24.7	16 DS1
20	15	1.2	18.5	12 DS1
10	10	1.2	12.3	8 DS1
5	5	1.2	6.2	4 DS1
2.5	2.5	1.2	3.1	2 DS1
2.5	1.5	1.0	1.5	1 DS1 or fractional T1

DS1 = 1.54 Mbits/Second STS-1 = 51.8 Mbits/Second
DS3 = 44.7 Mbits/Second OC-3 = 155.5 Mbits/Second

Very low data rate systems carrying less than 2 DS1 should be type notified for the necessary bandwidth of the radio and should be frequency coordinated using 2.5 MHz channels.

As discussed in Section 5. above, radios in the 18, 23, and 38 GHz bands use many common parts. Most manufacturers use 4-level frequency shift keying (4 FSK) or 4-level quadrature amplitude modulation (4 QAM) in their high frequency radio products. The radios are designed to meet the 1 bit/second per Hertz spectrum efficiency requirement in the 18 GHz band.

Radios using 4 QAM modulation will meet the spectrum efficiency requirement in the 23 GHz band without modification. Radios using 4 FSK may be modified to meet 1 bit/second per Hertz by reducing the frequency deviation if they do not currently meet the requirement. Radios using 2 FSK or other simple modulation techniques may require more extensive equipment changes. The proposed rules include the Transition Period before the new standard is effective, providing manufacturers with time to make modifications to their equipment and users with the time to implement the new technology.

The TIA Fixed Section anticipates demand for very high bit rate applications in the 23 GHz band carrying up to 155 Megabits per second of data traffic. These systems will carry high speed Local Area Network traffic between buildings on a university or corporate campus, interconnect LMDS cell sites, or serve as microcell feeder links in a cellular or PCS network. These systems may be implemented using the 50 MHz channels in the proposed frequency plan. Radio equipment for these applications will require spectrum efficiencies from 1 to 3 bit/second per Hertz (e.g., using 16 QAM modulation).

The TIA Fixed Section does not recommend that the spectrum efficiency rules be applied to the 38 GHz band. Figure 8 is a plot of propagation outage time vs. path length for a typical digital radio in the 38 GHz band, assuming 1 and 2 foot diameter antennas and typical rain rates. As shown in the plot, rain outage limits practical path lengths to approximately 1 mile for a typical 99.999% path reliability. Licensees in the 38 GHz band may prefer to use less spectrally efficient modulation techniques to extend the maximum path length.

After the Commission auctions the 38 GHz band, most licensees operating in the band will have purchased the exclusive rights to the spectrum within their service area. Licensees should be granted the maximum flexibility in their use of the spectrum, provided that such operation does not cause excessive interference to other licensees in the band. Spectrum efficiency rules should be applied to shared bands, like 18 and 23 GHz, but not to auctioned bands.

7. Low Power, Limited Coverage Systems in the 23 GHz Band

When Part 101 was adopted, the FCC moved the 23 GHz band regulations for low power, limited coverage systems from Section 94.91 to Section 101.147(s).[21] No changes were made in the regulations at that time. The TIA Fixed Section recommends that the FCC make the following modifications to Section 101.147(s) to bring the low power, limited coverage regulations up to date. The proposed rule changes are shown in Appendix B, Section 101.147(s)(8).

[21] *Part 101 Report and Order*, 11 FCC Rcd at 13574-628.

7.1 Maximum Power Definition

To qualify as a low power system under the current low power, limited coverage regulations in Sections 101.147(s)(1) and (2), the maximum E.R.P. must be less than 55 dBm and the transmitter power must be less than 0.1 Watt. The TIA Fixed Section recommends changing the definition of maximum power to the following:

The maximum EIRP shall be 55 dBm.

Maximum power for point-to-point microwave systems is normally expressed as an EIRP. For example, Section 101.113(a) specifies the maximum power for each frequency band in terms of EIRP. Similarly, Section 101.143(b) provides an equation to calculate the maximum power on short microwave paths, expressed as an EIRP. The FCC license application requires calculating the EIRP for each transmitter (Form 415, Schedule B, line B13).

The Maximum Effective Radiated Power (E.R.P) is the power relative to a dipole antenna. E.R.P. specifications are normally used for mobile systems. The conversion between the two units is E.R.P. = EIRP + 2.1 dB.

The maximum power specification for low power, limited coverage systems is based on a 0.1 Watt transmitter power and a 1 foot parabolic dish antenna. Calculating in terms of EIRP:

20.0 dBm (0.1 Watt transmit power)
34.8 dBi (typical antenna gain, high performance 1-foot antenna, Andrew Corporation)
54.8 dBm (EIRP power level)

The Section 101.147(s)(4) antenna standards were specifically drafted to permit 1 foot antennas in this service, particularly in perimeter security and remote monitoring applications where the path distances are short and an unobtrusive antenna is required. An EIRP standard of 55 dBm will allow 1 foot antennas to be used for low power, limited coverage systems. The current E.R.P. standard of 55 dBm cannot be met using typical high performance antennas without reducing the transmit power below 0.1 Watt.

The TIA Fixed Section also recommends deleting the 0.1 Watt transmitter power definition from Section 101.147(s)(2). Maximum transmitter power specifications were deleted from various provisions in Part 21 and Part 94, when they were consolidated into Part 101. For example, Section 94.73 previously listed a maximum transmitter power specification for each frequency band. These specifications are deleted in the equivalent table in Section 101.113(a), in which the FCC adopted a single definition of maximum power in terms of EIRP. It is unnecessary to specify a maximum transmit power when a maximum EIRP is specified, since the power out of the antenna is the important criterion in evaluating intersystem interference.

7.2 Frequency Tolerance

Currently, the frequency tolerance specification for low power, limited coverage systems in Section 101.147(s)(3) is 0.05%. This tolerance is even worse than the 0.03% specification used for other services in the 23 GHz band. To prevent excessive frequency drift into adjacent channels, it is extremely important to set a uniform frequency tolerance standard of 0.001% covering all shared services in the band.

The TIA Fixed Section's proposed rules in Section 101.139(g) and 101.147(s)(8)(ii) require low power, limited coverage systems to meet the new frequency tolerance requirements in Section 101.107(a). The rules also establish the Transition Period before the new standard becomes effective, allowing manufacturers 18 months to make modifications to their equipment and license applicants 24 months to apply for new stations using the 0.05% specification. The proposed rules allow existing stations to operate after the 24 month Transition Period with the lower 0.05% tolerance, provided that their operation does not cause harmful interference to other licensees.

7.3 Antenna Standards

Section 101.147(s)(4) exempts low power, limited coverage systems from the antenna standards of Section 101.115, provided that the maximum beamwidth does not exceed 4 degrees and the antenna front-to-back ratio is at least 38 dB. This exemption allows 1 foot antennas to be used in the 23 GHz band. In Section 8. below, the TIA Fixed Section proposes new antenna standards in Section 101.115 that permits 1 foot antennas to be used across the entire 23 GHz band. Under these proposed antenna standards, a special exclusion for low power, limited coverage systems is unnecessary and should be deleted.

The TIA Fixed Section's proposed rule in Section 101.147(s)(8)(iv) requires that low power, limited coverage systems meet the modified antenna standards in Section 101.115 after the 24 month Transition Period. The proposed rule also allows existing stations to operate after the 24 month Transition Period under the old antenna standards.

7.4 Special Showings

In Section 101.147(s)(5) and (6), the FCC requires special showings to be included with the license application if a 50 MHz bandwidth channel is requested or if a system has more than 5 hops in tandem. The TIA Fixed Section recommends deleting both of these paragraphs.

The proposed 1 bit/second per Hertz spectrum efficiency rule will encourage licensees to use narrow band channels for low capacity traffic. An operator will only license a 50 MHz channel if traffic requirements justify the higher cost of the higher bit rate equipment. As a result, a special showing for the use of 50 MHz channels is not needed and Section 141.147(s)(5) should be deleted.

With respect to the requirement for a special showing if a system has more than 5 hops in tandem, Figure 7 plots propagation outage time vs. path length for a typical digital radio in the 23 GHz band. The top curve shows the total annual outage due to multipath and rain fading, assuming 1 foot diameter antennas at each station. From the curve, the maximum path length for 99.999% reliability is 1.6 miles. It is not practical to build long tandem systems under the provisions of the low power, limited coverage service if path lengths are limited to 1.6 miles. Thus, Section 141.147(s)(6) requiring a special showing for systems with more than 5 hops in tandem is unnecessary and should be deleted.

7.5 Interference Criteria

In Section 101.147(s)(7), the FCC specifies additional interference criteria for low power, limited coverage systems. These criteria set a maximum interfering power level at the receiver of -90 dBm for a co-channel interference and -70 dBm for an adjacent channel interference. Section 141.147(s)(8) requires coordination of frequencies using Section 101.105 procedures (i.e., using the methods from TIA Bulletin 10F). [22]

The following is an interference analysis of two typical low power, limited coverage 23 GHz radios using TIA Bulletin 10F methods:

7.5.1 High Data Rate Interference Example

A 4 QAM digital radio operating at a data rate of 44.7 Mbits/second (1 DS3) has a receiver threshold (T) of -76 dBm, a co-channel Threshold-to-Interference (T/I) ratio of 23 dB, and an adjacent channel T/I ratio of 0 dB. The receiver threshold is the signal level that will result in a continuous 10^{-6} bit error rate. The Threshold-to-Interference ratio defines the interference level that will degrade the receiver threshold by 1 dB.

Using the TIA Bulletin 10F procedure, the maximum interfering power level for a like modulated co-channel interference is: T - (T/I) = -76 - 23 = -99 dBm. This level is significantly below the -90 dBm criterion.

For an adjacent channel interference, the maximum interfering power level is T - (T/I) = -76 - 0 = -76 dBm. This level is below the -70 dBm criterion.

7.5.2 Low Data Rate Interference Example

Radios operating at data rates less than 1 DS3 typically have the same co-channel and adjacent channel T/I ratios as a 1 DS3 radio, but have a lower receiver threshold. For example, a 4 QAM radio operating at 6 Mbits/second (4 DS1) has a receiver threshold of -84 dBm, a co-channel T/I ratio of 23 dB, and an adjacent channel T/I of 0 dB.

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[22] *TIA Bulletin 10F, Interference Criteria for Microwave Systems*, Document TSB-10-F, Telecommunications Industry Association (1994) ("*TIA Bulletin 10F*"), Section 3.5.6.

The maximum interfering power level for co-channel interference is: T - (T/I) = -84 - 23 = -107 dBm. The maximum interfering power level for adjacent channel interference is: T - (T/I) = -84 - 0 = -84 dBm. Therefore, low data rate radios are coordinated for much lower levels of interference then high data rate radios and they meet the -90 dBm and -70 dBm interference criteria by a wide margin.

7.5.3 Recommendations

The above analysis shows that the additional interference criteria in Section 101.147(s)(7) are met in all cases for typical radios and are unnecessary. Section 101.147(s)(8) is only a reference to Section 101.105. Therefore, the TIA Fixed Section recommends deleting Sections 101.147(s)(7) and (8).

A uniform frequency coordination procedure should be used for all services in the 23 GHz band. If special coordination procedures are required for the low power, limited coverage service, such procedures can be added to TIA Bulletin 10.

8. Antenna Standards for the 10 GHz and 23 GHz Bands

8.1 10 GHz Band

The primary purpose of this Petition for Rule Making is to provide alternatives to the microwave operator which plans to use the 18 GHz band for short distance microwave paths but is unable to coordinate frequencies due to the increasing number of satellite earth stations in the band. The TIA Fixed Section identified various impediments in the FCC's rules concerning alternative frequency bands. One impediment is the antenna standards for the 10 GHz band.

A key advantage to the 18 GHz band is the user's ability to use small 2 foot antennas. Under the current Section 101.115(c) antenna standards, 2 foot antennas are not permitted in the 10 GHz band. Antenna standards thus should be changed to permit 2 foot antennas in the 10 GHz band.

Many microwave operators need to use small antennas. For example, PCS operators are designing microcell networks in their service areas and plan to use point-to-point microwave to interconnect cell sites. Many sites are located on rooftops, monopoles, electrical transmission towers, and other structures that cannot support large microwave dishes. In addition, many homeowner associations and zoning boards voice complaints concerning the aesthetic appearance of numerous cell sites in their neighborhoods. PCS operators prefer to use small antennas, if possible, to respond to the concerns of these potential customers.

Figures 5, 6, and 7 compare the performance of typical digital radios in the 10, 18, and 23 GHz bands. Assuming a 99.999% reliability, path lengths up to 5.7, 3.8, and 2.3 miles can be installed in the 10, 18, and 23 GHz bands, respectively, using 2 foot antennas. These results indicate that the 10 GHz band would be a very important alternative to the 18 GHz band for paths longer than 2.3 miles if the antenna standards are changed to permit smaller antennas.

Under the current provisions of Section 101.115(c), antennas in the 10 GHz band must either: (i) have a minimum antenna gain of 38 dBi, or (ii) a maximum beamwidth of 2.2 degrees. These provisions effectively set a minimum antenna size of 4 foot in the band, and prevent the use of 2 foot antennas.

The TIA Fixed Section proposes the following changes to the antenna standards in Section 101.115(c) to permit 2 foot antennas:

- Change the minimum gain from 38 to 33.5 dBi. The proposed minimum gain is consistent with the recommendations in the FCC Report and Order on Directional Antennas for the 10 GHz band.[23]
- Change the maximum beamwidth from 3.4 to 3.5 degrees. This minor change sets a uniform beamwidth standard for all 10 GHz systems, including grandfathered DEMS systems in the 10.63 to 10.68 GHz band.
- Restore the antenna radiation standards for Category A and Category B to the same standards that applied to the 10.55 - 10.68 GHz band before June 1, 1997. However, tighten the front-to-back ratio for Category B. The proposed radiation standards will allow a shrouded 2 foot high performance antenna to meet Category A and will allow an unshrouded 4 foot standard antenna to meet Category B.

Before Part 101 was adopted, the 10 GHz antenna standards were less stringent then the current standards and 2 foot antennas were permitted in the band. When Part 101 was adopted, the antenna standards were tightened to promote spectrum efficiency.[24] However, the TIA Fixed Section believes that the benefits of using 2 foot antennas outweigh the cost of reduced spectrum efficiency. Consequently, it recommends changing the 10 GHz antenna standards in Section 101.115(c) to provide an alternative to the 18 GHz band for paths 3 to 6 miles in length.

8.2 23 GHz Band

The antenna standards in Section 101.115(c) set a minimum antenna size of 2 foot for the 23 GHz band, except in the small segment of the band allocated for low power, limited coverage systems. The TIA Fixed Section recommends changing the antenna standards for the entire 23 GHz band to allow 18 inch high performance antennas under the Category A standard for congested areas, and to allow 1 foot high performance antennas under the Category B standard.

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[23] *Amendment of Parts 74, 78, 101 of the Commission's Rules to Adopt More Flexible Standards for Directional Microwave Antennas, Report and Order*, 12 FCC Rcd 1016,1035 (1997) ("*Directional Antennas Report and Order*").

[24] *Part 101 Report and Order*, 11 FCC Rcd at 13474-75.

The proposed rules are listed in Appendix B, Section 101.115(c), and include the following changes:

- Change the minimum antenna gain from 38 to 33.5 dBi. Several U.S. antenna manufacturers recommended the 33.5 dBi specification to the TIA Fixed Section based on their practical experience in designing 1 foot antennas for international markets.
- Change the maximum beamwidth from 2.2 to 3.3 degrees.
- Retain the same Category A front-to-back ratio as the current radiation standards, tighten the Category B front-to-back ratio, and reduce the sidelobe suppression requirements to allow smaller antennas.

The TIA Fixed Section anticipates a need for extremely short point-to-point microwave paths (e.g., 1 to 2 miles) for microcell interconnects and LMDS infrastructure links. Small 18 inch and 1 foot antennas in the 23 GHz band provide sufficient path reliability for these applications, while maintaining a low visual profile. In the past, 1 mile paths were installed in the 38 GHz band using 1 and 2 foot antennas. However, it is uncertain if the 38 GHz band will be available for point-to-point paths in the future if the band is heavily used by point-to-multipoint and mobile systems.

The TIA Fixed Section notes that Canada recently adopted new antenna standards for the 23 GHz band, which permit the use of 1 foot antennas in uncongested areas.[25] The United Kingdom Radio Communications Agency also permits 1 foot antennas in the 23 GHz band.[26] Harmonizing FCC regulations with other countries allows U.S. antenna and radio manufacturers to design common products for domestic and foreign markets, obtain economies of scale, and increase competitiveness. For these reasons, the TIA Fixed Section recommends that the Commission adopt the proposed 23 GHz band antenna standards.

9. Table of Maximum Authorized Bandwidth (Part 101, Subpart C)

In Section 101.109(c) of its rules, the FCC specifies a maximum authorized bandwidth of 100 MHz for the 23 GHz band. The TIA Fixed Section proposes that the FCC reduce the maximum bandwidth from 100 MHz to 50 MHz to be consistent with the proposed 23 GHz frequency plan, which defines channels up to 50 MHz in bandwidth. The maximum bandwidth in the 38 GHz band is also 50 MHz. Establishing the same 50 MHz maximum bandwidth in the 23 GHz band and 38 GHz band will allow radio manufacturers to use common hardware in the two bands, and thereby increase economies of scale and reduce costs for the microwave operator.

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[25] *Technical Requirements for the Fixed Line-of-Sight Radio Systems Operating in the Bands 21.8-22.4 GHz and 23.0-23.6 GHz*, Industry Canada Technical Standard SRSP-321.8, 19 July 1997 at p. 8.

[26] U.K. Radio Communications Agency, Performance Specification MPT 1409, Figure 3.2.

A search of the emission designators in the FCC license data base identified no existing systems licensed for more than 50 MHz of bandwidth in the 23 GHz band. Therefore, no grandfathering provision for 100 MHz bandwidth is included in the TIA Fixed Section's proposed rules in Section 101.109(c).

The TIA Fixed Section also proposes several minor changes to the table of maximum authorized bandwidth in Section 101.109(c). First, it recommends adding existing footnote /1/ to the line for the 23 GHz band. This footnote states:

> */1/ The maximum bandwidth that will be authorized for each particular frequency in this band is detailed in the appropriate frequency table in §101.147.*

This footnote is necessary to reference the proposed new frequency plan in the 23 GHz band.

Second, the TIA Fixed Section recommends deleting footnote /4/. This footnote is only used in the line for the 23 GHz band in the table. Footnote /4/ references Section 101.147(t), which is a list of frequency bands available for LMDS systems. This list is not applicable to the 23 GHz band.

10. Local Television Transmission Service (Part 101, Subpart J)

10.1 Frequencies

Section 101.803 includes two tables of available frequencies. Paragraph (a) contains a table of frequencies for television pickup stations and paragraph (d) contains a table for television STL stations. Footnote /5/ of paragraph (a) states that half the 23 GHz band is reserved for Common Carriers and the other half is reserved for Private Operational Fixed users. The same statement is made in footnote /8/ of paragraph (d).

As discussed in Section 4. above, the TIA Fixed Section recommends that the entire 23 GHz band must be shared equally by Common Carrier and Private Operational Fixed users. To implement this change for the Local Television Transmission Service, the TIA Fixed Section recommends revising footnote /5/ of paragraph (a) and footnote /8/ of paragraph (d) to read as follows:

> *This frequency band is shared with the common carrier and private-operational fixed point-to-point microwave services.*

In Section 101.803(a), the last sentence of footnote /5/ specifies a maximum power of +45 dBW in the 14.2 to 14.4 GHz band. It is not clear why this sentence is included in a footnote concerning the 23 GHz band. In the proposed rules, this sentence is moved to a new footnote /8/.

In Section 101.101, the 2.45-2.5 GHz band is erroneously listed as available to the Local Television Transmission Service ("LTTS"). This band is not listed in the frequency tables of Section 101.803 as an LTTS band. Section 101.101 also shows the 2.45-2.5 GHz band as available to the Private Operational Fixed Service, but not to the Common Carrier Fixed Service. This omission appears to be an oversight in the consolidation of Part 21 and Part 94 into Part 101. The TIA Fixed Section recommends deleting the Local Television Transmission Service and adding the Common Carrier Fixed Service to the list of available services for the 2.45-2.5 GHz band in Section 101.101. It also recommends correcting the frequency table in Section 101.147(a) by changing the footnote reference from /26/ to /12/ for the 2.45-2.5 GHz band.

10.2 Bandwidth and Emission Limitations

The TIA Fixed Section recommends adding the following footnote to the table of maximum authorized bandwidth in Section 101.809:

> */1/ The maximum bandwidth that will be authorized for each particular frequency in this band is detailed in the appropriate frequency table in §101.147.*

The same footnote is currently used in the table of maximum authorized bandwidth in Subpart C, Section 101.109. This footnote clarifies that the standard frequency channelization plans for the 3.7-4.2 GHz, 5.925-6.425 GHz, 10.7-11.7 GHz, and 21.2-23.6 GHz bands also apply to the Local Television Transmission Service.

The proposed rules for Section 101.809 correct an error in the frequency range for the 23 GHz band. The current rules specify the lower limit of the band as 22,000 MHz. The correct range is 21,200-23,600 MHz.

11. Obsolete References to FCC Parts 21 and 94

The regulations for the Common Carrier and Private Operational Fixed Point-to-Point Microwave Services have been removed from Part 21 and Part 94, respectively, and consolidated into Part 101. Regulations concerning inter-service frequency coordination between the point-to-point microwave services and the Part 25 Satellite Communications Service, the Part 74 Broadcast Auxiliary Services, the Part 78 Cable Television Relay Service (CARS), and the Part 90 Private Land Mobile Radio Services also have been consolidated into Part 101.[27] However, Parts 25, 74, 78, and 90 continue to reference the old section numbers in Parts 21 and 94. The TIA Fixed Section recommends correcting the obsolete references in Parts 25, 74, 78, and 90 to complete the Part 101 consolidation process.

Figure 10 lists the obsolete and corrected references for each rule section. Appendix B includes the proposed rule changes to Parts 25, 74, 78, and 90.

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[27] 47 C.F.R. §101.103(d) (1998).

12. Television Broadcast Auxiliary Service (Part 74, Subpart F)

12.1 Digital Modulation in the 2 GHz, 7 GHz, and 13 GHz Bands

The frequency bands from 6.875-7.125 GHz and from 12.7-13.25 GHz in the Television Broadcast Auxiliary Service are the most heavily used bands for Studio-to-Transmitter Links ("STL"). Currently, most STL systems in these bands use frequency modulated analog radios carrying NTSC video. Under the new digital television regulations, broadcasters will need to transport a High Definition Television ("HDTV") digital signal along with their existing NTSC analog signal on STL microwave paths. This is possible using a digital radio with a hybrid NTSC/HDTV multiplex.

Broadcasters use the 1.990-2.110 GHz and 2.450-2.4835 GHz bands for Electronic News Gathering ("ENG") to relay NTSC analog video from mobile news vans and helicopters to local studios. ENG relay links often include fixed point-to-point microwave paths (e.g., from a broadcast tower to a studio location). In the future, broadcasters will need to transport HDTV digital signals over mobile ENG radios and over fixed point-to-point microwave paths in the 2 GHz band.

However, Section 74.637(c) only allows digital modulation in the 6.425-6.525 GHz, 17.7-19.7 GHz, and 31.0-31.3 GHz bands. Digital modulation is not permitted in the 1.990-2.110 GHz, 2.450-2.4835 GHz, 6.875-7.125 GHz and 12.7-13.25 GHz bands. To correct this omission, the TIA Fixed Section recommends changing Section 74.637(c) to permit digital modulation in all Television Broadcast Auxiliary bands.

This change would result in more complex frequency coordination for the local Broadcast Auxiliary coordinating committees since analog and digital systems would coexist in the same frequency bands. However, analog and digital systems have coexisted in the Part 101 frequency bands for many years, using the same types of modulation as in the proposed Part 74 systems.[28] Band sharing of digital and analog systems in the Part 74 bands is clearly feasible if proper frequency coordination is performed.

12.2 Technical Standards for the 2.110 - 2.130 GHz Band

When the FCC reallocated the 2.110 - 2.130 GHz band to the Broadcast Auxiliary Service, it defined a new frequency plan for the reconfigured 2.025 - 2.130 GHz Broadcast Auxiliary band. The new frequency plan will become effective January 1, 2000, or after the last Common Carrier incumbent is relocated from the 2.110 - 2.130 GHz band, whichever is later.[29] However, the FCC does not specify other technical standards for 2.110 - 2.130 GHz frequency range.

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[28] Frequency coordination methods for the Part 101 frequency bands are defined in *TIA Bulletin 10F*.

[29] 47 C.F.R. §74.602(a)(3) (1998).

The TIA Fixed Section recommends that the existing Part 74 technical standards for transmitter power, EIRP, antennas, and frequency tolerance be applied to the 2.110 - 2.130 GHz frequency range. The proposed rules are shown in Appendix B, Sections 74.602(a), 74.636, 74.637(g), 74.641, 74.644(a), and 74.661.

The proposed rule in Section 74.637(g) adds a footnote to the table of maximum authorized bandwidth specifying a 15 MHz maximum bandwidth for the 2.025 - 2.130 GHz band after the new frequency plan becomes effective. The FCC added a similar footnote to Part 78.103(e) in the Cable Television Relay Service.[30]

12.3 Maximum EIRP for Short Paths

In Section 74.644, the maximum EIRP limits for short microwave paths are defined for the Television Broadcast Auxiliary Service. Different limits are defined for different frequency bands. For example, in the 6.875-7.125 GHz band, Section 74.644 requires reduction of the EIRP from +55 dBW to +30 dBW or less for paths shorter than 17 kilometers. The maximum EIRP for short paths is specified by the equation: 30 - 20 log (A/B) in dBW, where the variable A is 17 kilometers in the 6.875-7.125 GHz band and 5 kilometers in the 12.7-13.25 GHz band. The variable B is the path length in kilometers.

The equation for maximum EIRP in Section 74.644(b) is the same equation used in the old Part 21 Common Carrier Point-to-Point Microwave and Part 94 Private Operational Fixed Point-to-Point Microwave regulations.[31] The Part 101 rulemaking record strongly supports a conclusion that the old equation for maximum EIRP is not appropriate for digital microwave systems.[32]

The steep 25 dB reduction in EIRP for paths slightly shorter than the 17 or 5 kilometer limit requires adding transmit attenuators to most paths. The transmit attenuators reduce the fade margin of the path and make it difficult or impossible to achieve high reliability objectives.

Based upon this rulemaking record, the Commission specified a new equation for maximum EIRP in Section 101.143(b).[33] The new equation for maximum EIRP is:
MAXEIRP - 40 log (A/B) in dBW, where MAXEIRP is the maximum EIRP for long paths (e.g., +55 dBW in most frequency bands). The new equation eliminates the abrupt 25 dB drop, but reduces the EIRP at a steeper rate than the old equation. This change allows high reliability to be achieved on paths slightly shorter than the 17 or 5 kilometer limit, while encouraging the use of higher frequency bands on short paths.

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[30] *MSS First Report and Order*, 12 FCC Rcd at 7388.

[31] 47 C.F.R. §21.710(b) (1995); 47 C.F.R. §94.79(b) (1995).

[32] *Part 101*, Joint Reply Comments of the National Spectrum Managers Association and the Fixed Point-to-Point Communications Section, Network Equipment Division of the Telecommunications Industry Association at p. 25.

[33] *Part 101 Report and Order*, 11 FCC Rcd at 13472-73.

The TIA Fixed Section recommends changing the maximum EIRP limit in Section 74.644(b), using the same equation as in Section 101.143(b). This change will allow high reliability on digital STL paths in the Part 74 bands and will prevent the problems encountered in the old Part 21 and 94 regulations.

12.4 Automatic Transmit Power Control

Automatic Transmit Power Control ("ATPC") is a method used in digital radios to reduce the normal transmit power by 10 dB or more during normal propagation conditions. When the microwave signal is reduced due to a multipath or rain fade, the far end receiver detects the reduction in signal level and sends a signal to the transmitter, instructing it to gradually increase the power. When the multipath or rain fade ends, the power is again reduced to its previous level.

ATPC provides a great benefit in reducing interference levels into other microwave paths, thereby allowing more frequencies to be coordinated in a particular geographic area. ATPC also protects against receiver overload from an excessively strong signal during abnormal propagation conditions. Digital radios will experience an outage if the signal level is too strong. By operating at a lower power level for most of the time, ATPC also reduces the power consumption of the radio, lowers operating costs, and increases equipment reliability.

ATPC has been used successfully in the Part 101 frequency bands for many years.[34] It is not clear if ATPC is permitted under the current Part 74 regulations. Thus, the TIA Fixed Section recommends permitting use of ATPC in the Television Broadcast Auxiliary Service and proposes a change in Section 74.651(a)(2) to clarify this issue.

13. Conclusion

The point-to-point microwave industry has faced many challenges in recent years. In the 1980's, fiber optic cable systems displaced point-to-point microwave as the preferred transmission medium for long distance telephone carriers. The industry adapted by developing new products for the emerging cellular and PCS markets, and by increasing export sales to European and third world countries.[35]

Private Operational Fixed customers, including electrical utilities, oil and gas companies, railroads, and state and local governments, demanded higher reliability in their transmission networks. The industry responded by developing ring switching and digital cross-connect technologies, allowing automatic rerouting of traffic around a radio ring in case of catastrophic failure (e.g., the loss of a microwave tower in a hurricane).

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[34] *Part 101 Report and Order*, 11 FCC Rcd at 13470.

[35] Point-to-point microwave manufacturers in the U.S. include: Alcatel Network Systems, Harris Corporation Farinon Division, Digital Microwave Corporation, California Microwave, and P-Com.

Local exchange carriers installed SONET fiber optic cable systems in their distribution networks.[36] The industry responded by developing SONET compatible microwave radios that can protect critical fiber optic links or extend SONET networks to areas where fiber optic cable is not available.

Emerging technologies required new spectrum in the 2 GHz band. The industry worked with the Commission to develop new regulations, channelization plans, and PCS coordination procedures for the point-to-point services. The industry also developed more spectrally efficient radios for the lower frequency bands and designed new products for the millimeter wave bands above 23 GHz.

Television broadcasters use point-to-point microwave extensively to carry NTSC analog video from studios to transmitters. Broadcasters are actively planning HDTV digital transmission networks and urgently require digital Studio to Transmitter Links. The point-to-point microwave industry developed radios capable of carrying analog and digital video on the same RF carrier. If the FCC adopts TIA Fixed Section's proposed Part 74 rule changes, broadcasters may deploy these radios in their transmission networks and thereby reduce their HDTV conversion costs.

Once again, the industry is faced with a new challenge. Teledesic is authorized to construct, launch, and operate a constellation of low earth orbit ("LEO") satellites in the 18 GHz band. Teledesic plans to offer high rate data services to 95% of the earth's surface that will compete with point-to-point microwave in some applications.[37] Numerous other satellite applications are being filed in the 18 GHz band, as well. LEO satellite networks, like Teledesic, will provide great benefits to third world countries with underdeveloped communications, to multinational corporations with world-wide operations, and to Internet users. However, it is important to recognize the limitations of LEO satellite systems.

Service reliability of the Teledesic network will be highly susceptible to rain fades, since the system will operate in the 18 GHz band. Rain fades affect all microwave systems above 8 GHz, and are most severe at high frequencies during intense thunderstorms. Service reliability is most at risk along the U.S. Gulf coast from Florida to New Orleans, which has the highest incidence of heavy thunderstorm activity.[38]

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[36] SONET (Synchronous Optical Network) is a North American multiplexing standard using a basic data rate of 51.84 Megabits/second. The basic rate is called an STS-1 for electrical interfaces and OC-1 for optical interfaces. Higher levels of multiplexing use an integral multiple of the basic rate. The most commonly used rates are OC-3, OC-12, OC-48, and OC-192. SONET compatible microwave radios typically interface at the STS-1 or OC-3 rates.

[37] *Teledesic Corporation Application for Authority to Construct, Launch, and Operate a Low Earth Orbit Satellite System in the Domestic and International Fixed Satellite Service, Order and Authorization,* 12 FCC Rcd 3154, 3156 (1997).

[38] R. K. Crane, *Prediction of Attenuation by Rain*, IEEE Transactions on Communications, Sept. 1980, at pp. 1717-1733.

It is possible to improve satellite reliability by using *site diversity*, in which multiple earth stations are installed and traffic is switched to the earth station with the best transmission path. Intense rain cells have a radius of 3 miles or less. As a result, earth station separations greater than 3 miles are required to obtain significant diversity improvement.[39] However, site diversity systems may be cost prohibitive, since they require the installation of multiple earth stations and a terrestrial communications link connecting the alternative sites.

Satellite systems are particularly useful in broadcast applications where the same information is transmitted to a large number of receive locations simultaneously. Satellites also are useful if information is transmitted on an intermittent basis to different locations over a wide area. However, satellite networks become congested when large numbers of earth stations attempt to transmit high data rate, continuous information simultaneously. This limitation is a basic constraint of the satellite network topology.

Within the spot beam of a typical satellite, hundreds of point-to-point microwave paths can be installed in a complex network, all transmitting different information and all sharing the same spectrum. Point-to-point systems are therefore more spectrally efficient for dense networks carrying high data rate, continuous information.

Point-to-point microwave systems employ much larger fade margins than satellite systems (e.g., 35 to 40 dB), and are thereby less susceptible to rain fades. Point-to-point systems may use ring networks to protect against rain fades and catastrophic failures. For high reliability applications, point-to-point systems may use lower frequency bands not affected by rain (e.g., 6 GHz).

The TIA Fixed Section concludes that the wireless network of the future will include a mixture of point-to-point, point-to-multipoint, geostationary satellite, and LEO satellite technologies. No one technology can do it all.

To support the future growth of short haul point-to-point microwave services, relieve frequency congestion due to increased satellite utilization of the 18 GHz band, and facilitate the frequency coordination process with the Federal Government, the TIA Fixed Section recommends that the FCC adopt its proposed Part 101 rule changes. The proposed 23 GHz band frequency plan and other rule changes will promote more efficient use of that band. However, the propagation characteristics of the 23 GHz band are significantly inferior to the 18 GHz band. The FCC must maintain continued access to the 18 GHz band by point-to-point and other terrestrial fixed services. It also must ensure that fixed users of the 18 GHz band are protected from satellite interference.

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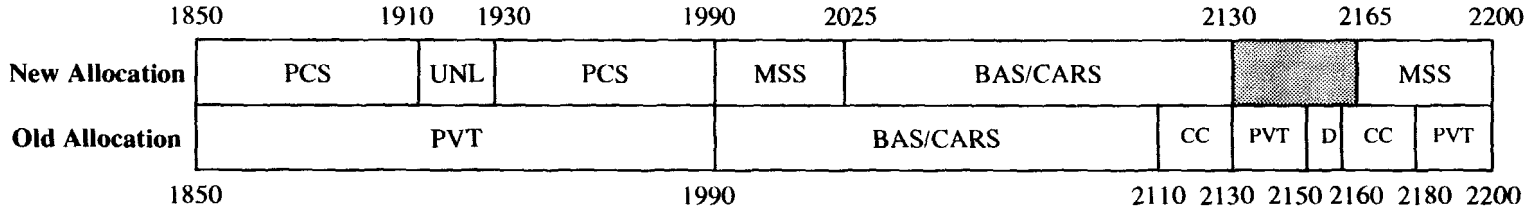
[39] *Propagation Data and Prediction Methods Required for the Design of Earth-Space Telecommunication Systems*, ITU-R Recommendation P.618-4, 1995 at pp. 255-256.

2 GHz Frequency Band

Fixed Microwave and Satellite Service Allocations



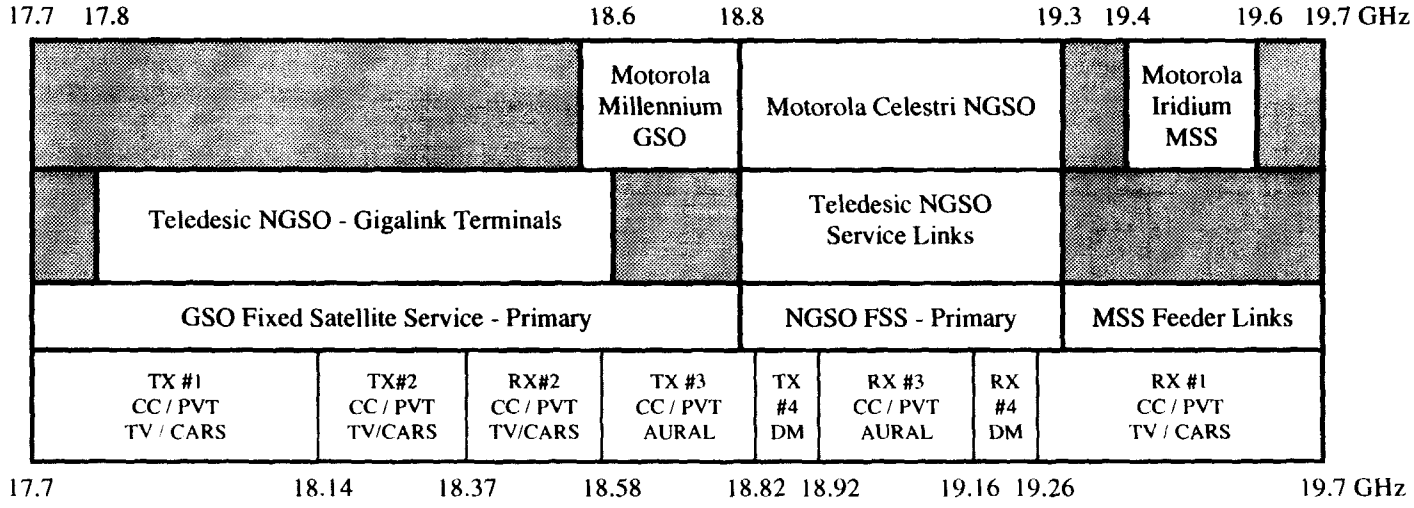
Frequency in MHz

Service	Description
UNL	Part 15 - Unlicensed Personal Communications Service
D	Part 21 - Multipoint Distribution Service
PCS	Part 24 - Licensed Personal Communications Service
MSS	Part 25 - Mobile Satellite Service
BAS	Part 74 - Broadcast Auxiliary Service
CARS	Part 78 - Cable Television Relay Service
CC	Part 101 - Common Carrier Point-to-Point Microwave Service
PVT	Part 101 - Private Operational Fixed Point-to-Point Microwave Service

Figure 1

18 GHz Frequency Band

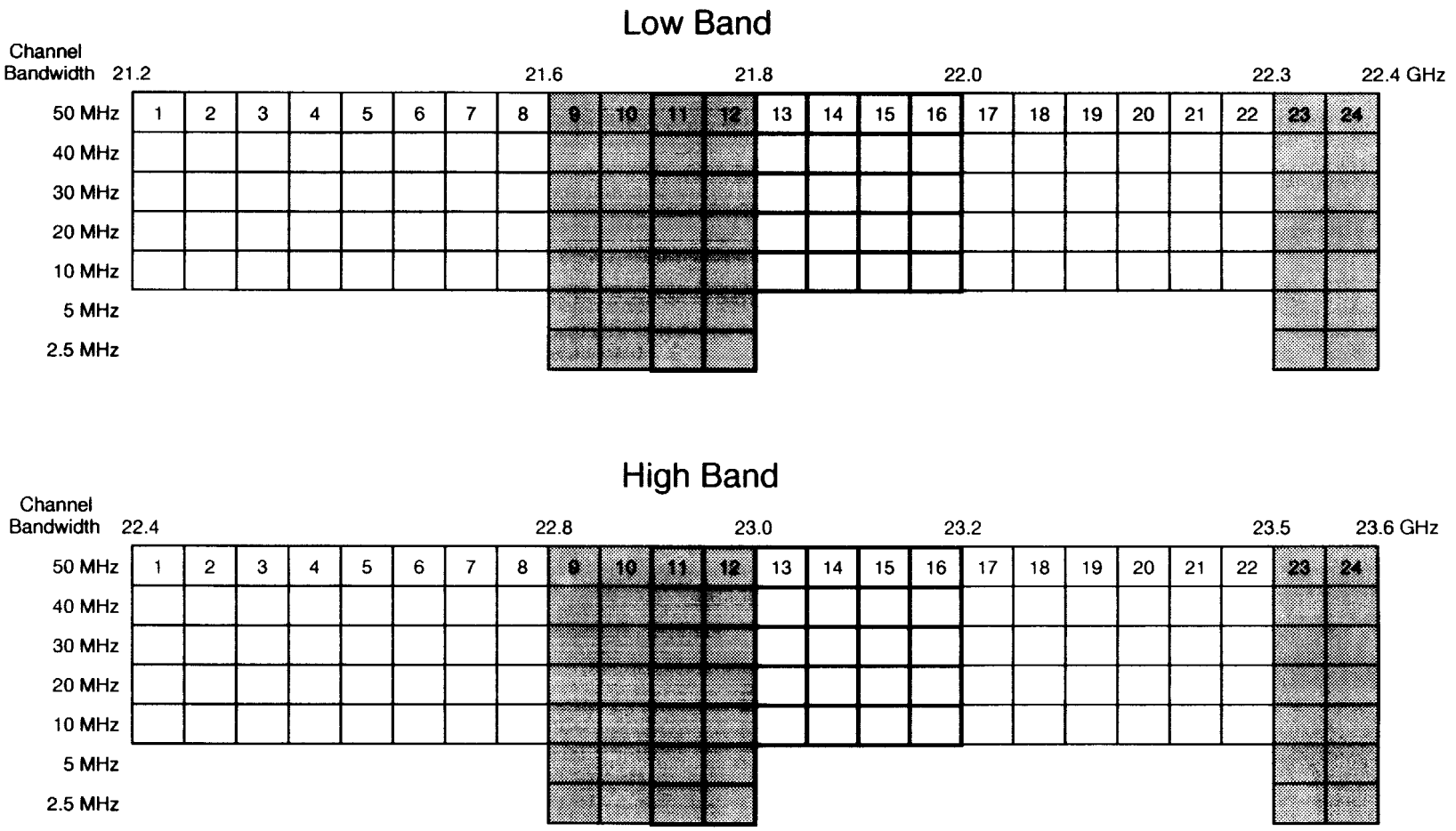
Fixed Microwave and Satellite Service Allocations



Service	Description
GSO	Part 25 - Geostationary Fixed Satellite Service
NGSO	Part 25 - Non-Geostationary Fixed Satellite Service
MSS	Part 25 - Mobile Satellite Service
TV	Part 74 - Television Broadcast Auxiliary Service
AURAL	Part 74 - Aural Broadcast Auxiliary Service
CARS	Part 78 - Cable Television Relay Service
CC	Part 101 - Common Carrier Fixed Point-to-Point Microwave Service
PVT	Part 101 - Private Operational Fixed Point-to-Point Microwave Service
DM	Part 101 - Digital Electronic Messaging Service (relocating to 24 GHz)

Figure 2

Proposed Frequency Plan for the 21.2 - 23.6 GHz Band



Frequencies subdivided into 50, 40, 30, 20, 10, 5, or 2.5 MHz channels.

Frequencies available for low power systems.

Frequencies reserved for narrow band systems (2.5 and 5 MHz bandwidths).

Figure 3.1

Proposed Frequency Plan for the 21.2 - 23.6 GHz Band

50 MHz Channels are sub-divided using the following pattern:

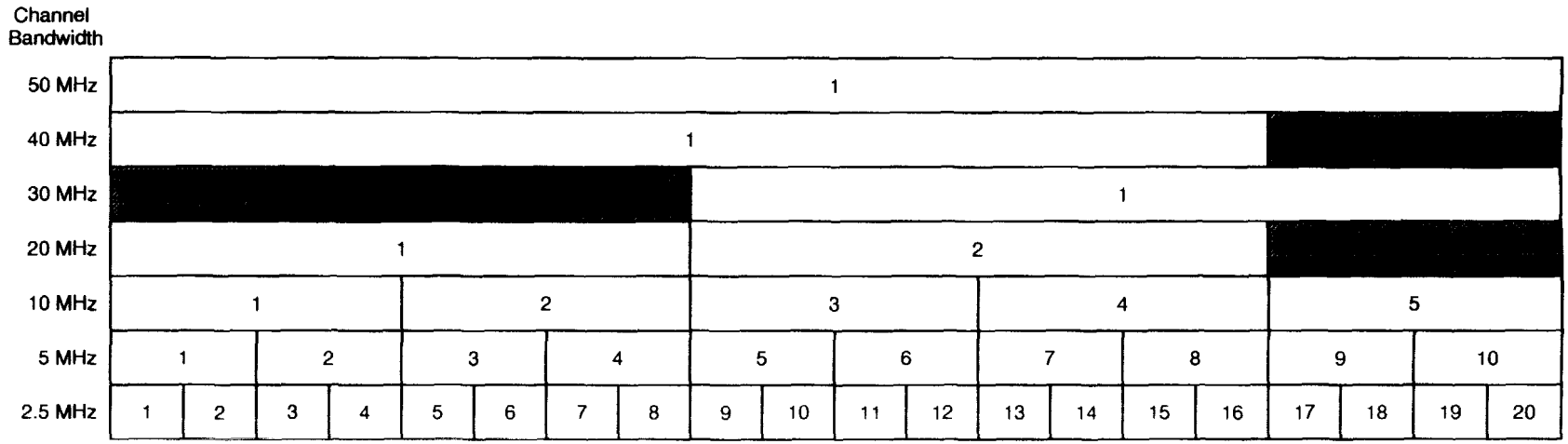
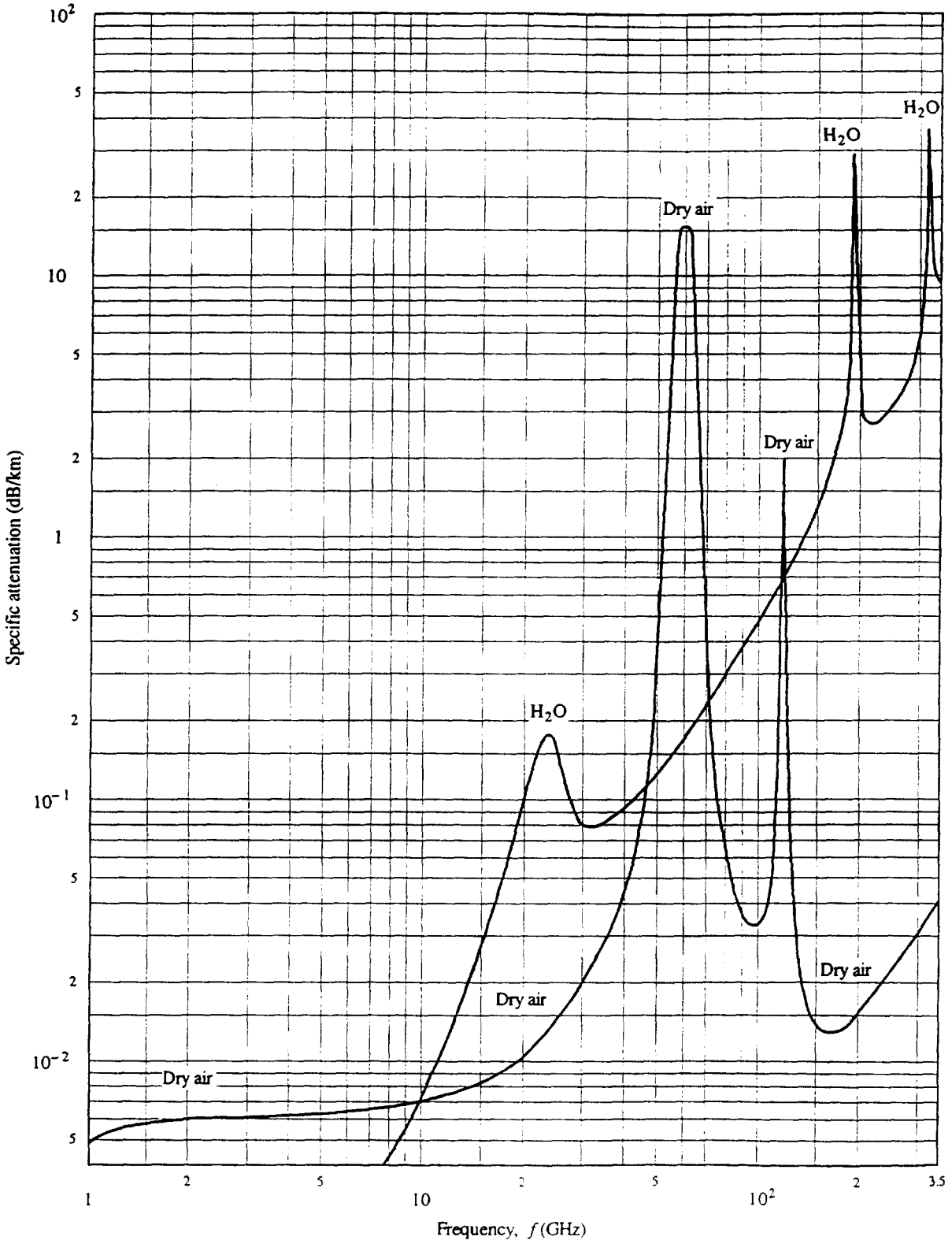


Figure 3.2

FIGURE 1

Specific attenuation due to atmospheric gases



Pressure: 1 013 hPa
Temperature: 15 °C

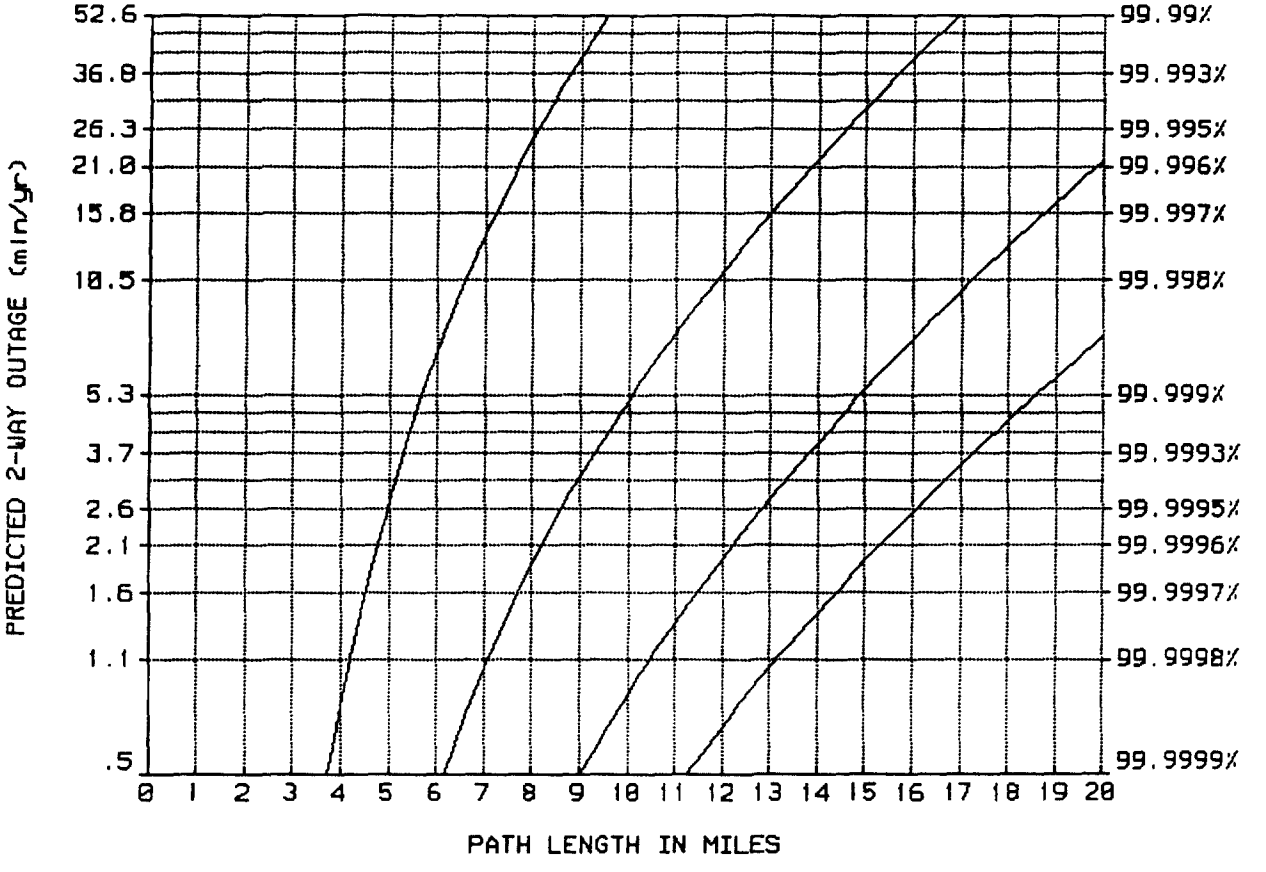
Figure 4

PROPAGATION OUTAGE vs PATH LENGTH 13 Jun 1997

RADIO TYPE: TYPICAL 10 GHZ - 16 DS1 DIGITAL

RAIN CURVE 202 PHILADELPHIA PENNSYLVANIA CRANE RAIN METHOD
INDOOR RADIO - 128 QAM WITH TRELLIS CODING - 5 MHZ BANDWIDTH

CURVE	ANTENNA SIZE	ANTENNA GAIN	RADOME TYPE	ANTENNA TYPE
TOP	2.0 FEET	34.1 dB	PLASTIC	TYPICAL
MIDDLE	4.0 FEET	39.9 dB	PLASTIC	TYPICAL
MIDDLE	6.0 FEET	43.5 dB	TEFLON	TYPICAL
BOTTOM	8.0 FEET	45.9 dB	TEFLON	TYPICAL



FREQUENCY:	10.6	Ghz		
FEEDER LOSS (TX SITE):	3.2	dB per 100 Feet		
FEEDER LOSS (RX SITE):	3.2	dB per 100 Feet		
FEEDER LENGTH (TX SITE):	100.0	Feet		
FEEDER LENGTH (RX SITE):	100.0	Feet		
RADIO TRANSMIT POWER:	27.0	dBM	FIELD MARGIN:	1.0 dB
RADIO OUTAGE THRESHOLD:	-73.0	dBM	OTHER LOSSES:	.5 dB
DISPERSIVE FADE MARGIN:	53.0	dB		
BER AT THRESHOLD:	10-6			
MEAN ANNUAL TEMPERATURE:	54.6	deg F		
ABSOLUTE HUMIDITY:	16.0	g/m^3		
CLIMATE FACTOR:	1.0		(.5=dry, 1=average, 2=coastal)	
PATH ROUGHNESS:	50.0	Feet	(20=flat, 50=average, 140=rough)	

RAIN OUTAGE CALCULATED FOR THE VERTICAL POLARIZATION

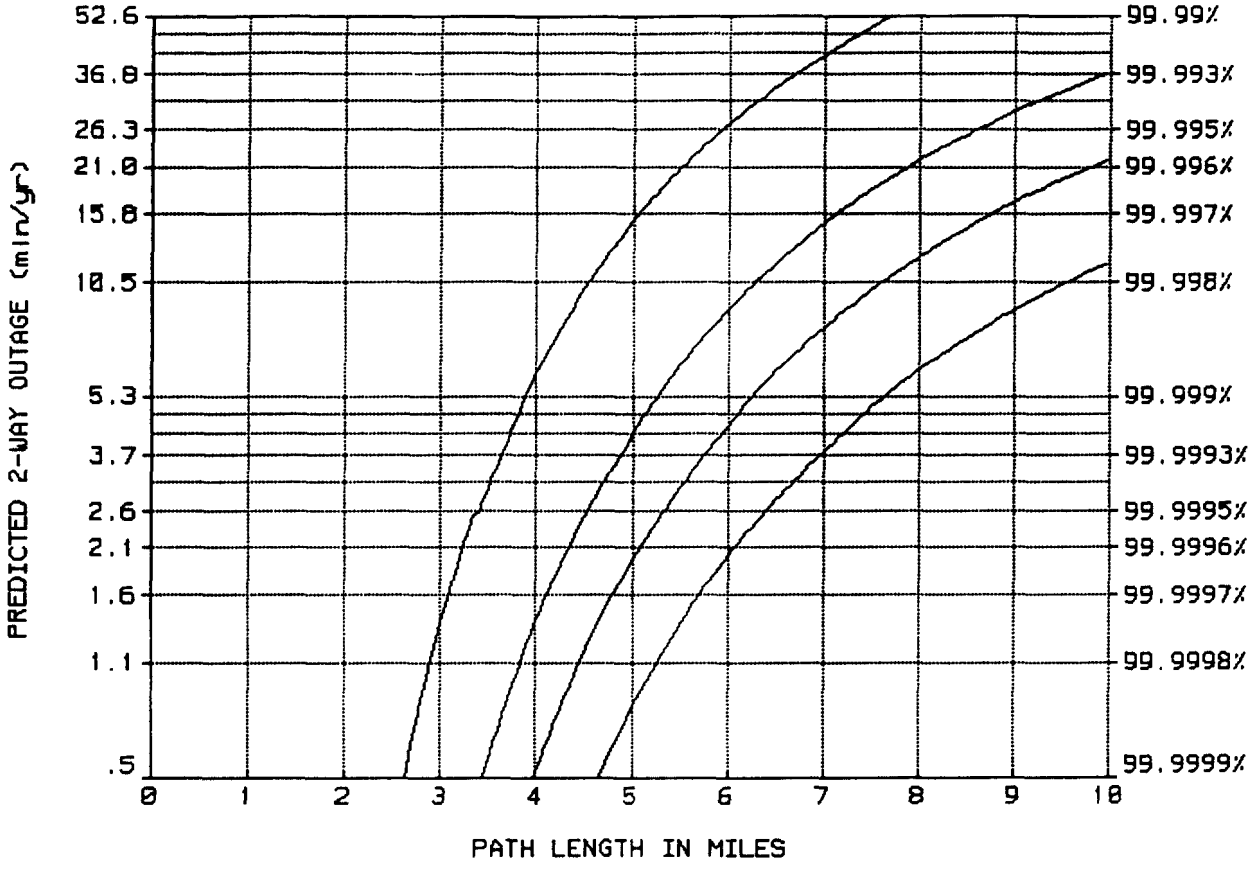
Figure 5

PROPAGATION OUTAGE vs PATH LENGTH 13 Jun 1997

RADIO TYPE: TYPICAL 18 GHZ - 16 DS1 DIGITAL

RAIN CURVE 202 PHILADELPHIA PENNSYLVANIA CRANE RAIN METHOD
OUTDOOR RF HEAD - 4 QAM - 20 MHZ BANDWIDTH

CURVE	ANTENNA SIZE	ANTENNA GAIN	RADOME TYPE	ANTENNA TYPE
TOP	2.0 FEET	38.7 dB	PLASTIC	TYPICAL
MIDDLE	4.0 FEET	44.6 dB	PLASTIC	TYPICAL
MIDDLE	6.0 FEET	48.0 dB	PLASTIC	TYPICAL
BOTTOM	8.0 FEET	50.3 dB	TEFLON	TYPICAL



FREQUENCY:	18.7	Ghz		
FEEDER LOSS (TX SITE):	0.0	dB per 100 Feet		
FEEDER LOSS (RX SITE):	0.0	dB per 100 Feet		
FEEDER LENGTH (TX SITE):	0.0	Feet		
FEEDER LENGTH (RX SITE):	0.0	Feet		
RADIO TRANSMIT POWER:	24.5	dBM	FIELD MARGIN:	1.0 dB
RADIO OUTAGE THRESHOLD:	-83.0	dBM	OTHER LOSSES:	.5 dB
DISPERSIVE FADE MARGIN:	0.0	dB		
BER AT THRESHOLD:	10-6			
MEAN ANNUAL TEMPERATURE:	54.6	deg F		
ABSOLUTE HUMIDITY:	16.0	g/m^3		
CLIMATE FACTOR:	1.0		(.5=dry, 1=average, 2=coastal)	
PATH ROUGHNESS:	50.0	Feet	(20=flat, 50=average, 140=rough)	

RAIN OUTAGE CALCULATED FOR THE VERTICAL POLARIZATION

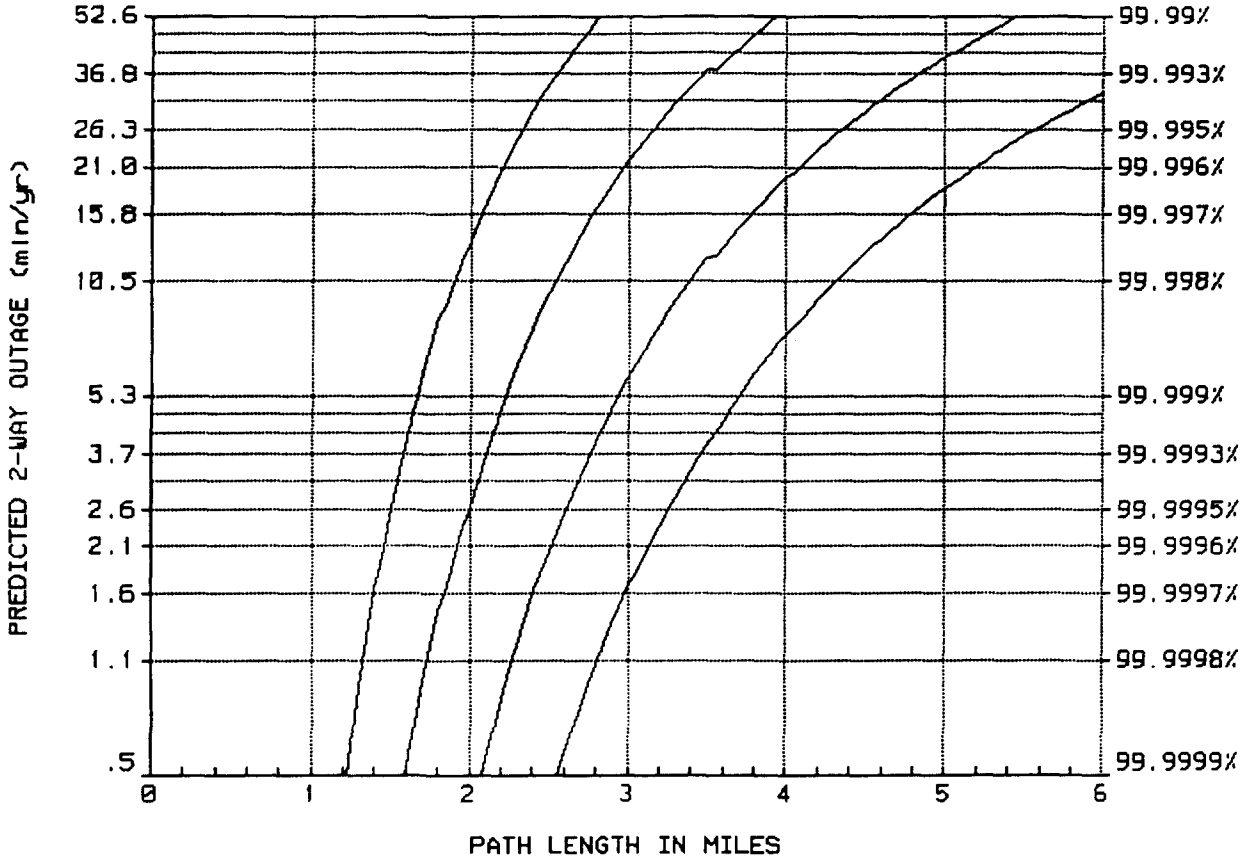
Figure 6

PROPAGATION OUTAGE vs PATH LENGTH 13 Jun 1997

RADIO TYPE: TYPICAL 23 GHZ - 16 DS1 DIGITAL

RAIN CURVE 202 PHILADELPHIA PENNSYLVANIA CRANE RAIN METHOD
OUTDOOR RF HEAD - 4 QAM - 20 MHZ BANDWIDTH

CURVE	ANTENNA SIZE	ANTENNA GAIN	RADOME TYPE	ANTENNA TYPE
TOP	1.0 FEET	34.8 dB	PLASTIC	TYPICAL
MIDDLE	2.0 FEET	40.1 dB	PLASTIC	TYPICAL
MIDDLE	4.0 FEET	46.1 dB	PLASTIC	TYPICAL
BOTTOM	6.0 FEET	49.8 dB	TEFLON	TYPICAL



FREQUENCY:	22.4	Ghz		
FEEDER LOSS (TX SITE):	0.0	dB per 100 Feet		
FEEDER LOSS (RX SITE):	0.0	dB per 100 Feet		
FEEDER LENGTH (TX SITE):	0.0	Feet		
FEEDER LENGTH (RX SITE):	0.0	Feet		
RADIO TRANSMIT POWER:	19.0	dBM	FIELD MARGIN:	1.0 dB
RADIO OUTAGE THRESHOLD:	-78.0	dBM	OTHER LOSSES:	.5 dB
DISPERSIVE FADE MARGIN:	0.0	dB		
BER AT THRESHOLD:	10-6			
MEAN ANNUAL TEMPERATURE:	54.6	deg F		
ABSOLUTE HUMIDITY:	16.0	g/m^3		
CLIMATE FACTOR:	1.0		(.5=dry, 1=average, 2=coastal)	
PATH ROUGHNESS:	50.0	Feet	(20=flat, 50=average, 140=rough)	

RAIN OUTAGE CALCULATED FOR THE VERTICAL POLARIZATION

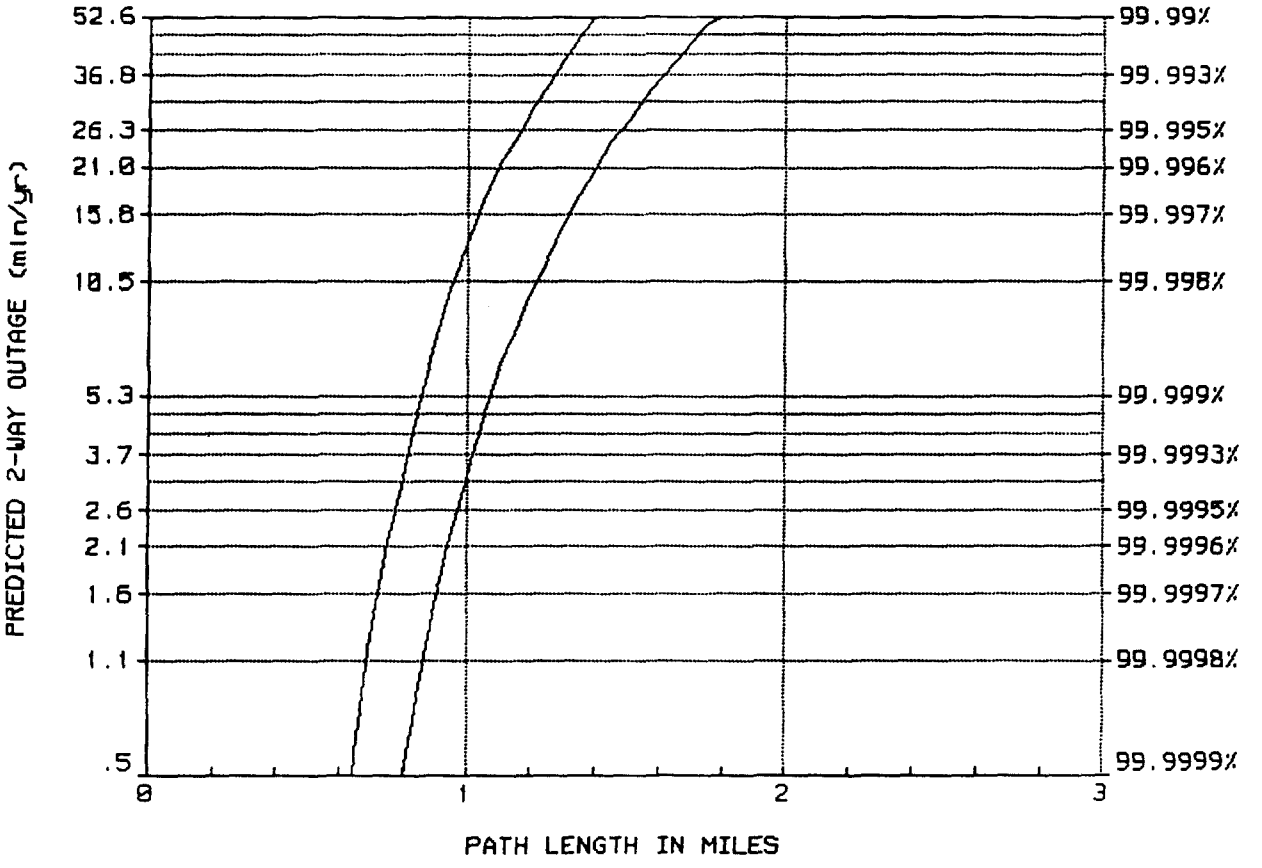
Figure 7

PROPAGATION OUTAGE vs PATH LENGTH 13 Jun 1997

RADIO TYPE: TYPICAL 38 GHZ - 16 DS1 DIGITAL

RAIN CURVE 202 PHILADELPHIA PENNSYLVANIA CRANE RAIN METHOD
OUTDOOR RF HEAD - 4 QAM - 20 MHZ BANDWIDTH

CURVE	ANTENNA SIZE	ANTENNA GAIN	RADOME TYPE	ANTENNA TYPE
TOP	1.0 FEET	39.5 dB	PLASTIC	TYPICAL
BOTTOM	2.0 FEET	44.3 dB	PLASTIC	TYPICAL



FREQUENCY:	39.3	Ghz		
FEEDER LOSS (TX SITE):	0.0	dB per 100 Feet		
FEEDER LOSS (RX SITE):	0.0	dB per 100 Feet		
FEEDER LENGTH (TX SITE):	0.0	Feet		
FEEDER LENGTH (RX SITE):	0.0	Feet		
RADIO TRANSMIT POWER:	16.0	dBM	FIELD MARGIN:	1.0 dB
RADIO OUTAGE THRESHOLD:	-73.0	dBM	OTHER LOSSES:	.5 dB
DISPERSIVE FADE MARGIN:	0.0	dB		
BER AT THRESHOLD:	10-6			
MEAN ANNUAL TEMPERATURE:	54.6	deg F		
ABSOLUTE HUMIDITY:	16.0	g/m^3		
CLIMATE FACTOR:	1.0		(.5=dry, 1=average, 2=coastal)	
PATH ROUGHNESS:	50.0	Feet	(20=flat, 50=average, 140=rough)	

RAIN OUTAGE CALCULATED FOR THE VERTICAL POLARIZATION

Figure 8